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Disaster and associated changes in physical and mental health in older residents

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Background: Long-term health consequences of disasters have not been studied extensively, one reason amongst others is that no pre-disaster observation is available. This study focuses on an aeroplane crash on an Amsterdam suburb. The ongoing Longitudinal Aging Study Amsterdam has one pre-disaster and several post-disaster observations, making it possible to study changes in health, taking pre-disaster health characteristics into account. **Methods:** Three exposure groups are distinguished: those living within a radius of 1 km from the disaster (initial $n = 39$), those living between a radius of 1 and 2 km from the disaster (initial $n = 56$), and those living in the rest of the city of Amsterdam (initial $n = 508$). Health measures include general health, health in comparison with age peers, functional limitations, disability and cognitive functioning. These measures are based on self-ratings, interviewer observations, or both. **Results:** Older persons living closest to the disaster area are likely to experience health decline in the wake of a disaster, over and above the health decline that would occur normally with aging. The disaster-associated health decline is small, and most obvious in the ability to perform actions (such as mobility), but is not observed in either disability in daily functioning, nor in self-perceptions of health. Cognitive functioning even shows a short-term improvement. **Conclusion:** These findings suggest substantial resilience in older adults, despite their common health problems.

Keywords: disaster, pre-post observation, health changes, older persons

On October 4, 1992, a cargo Boeing 747 crashed into two high rise apartment buildings in an Amsterdam suburb, the Bijlmer. Thirty-nine residents were killed, and many residents were directly or indirectly affected by the plane crash.

A man-made disaster such as the aeroplane crash in the Bijlmer may result in short-term and long-term health effects. Short-term effects include physical injuries due to the direct effects of exposure to the disaster, such as burns and fractures. These may result in long-term somatic complaints. Other short-term effects include psychological stress symptoms, such as intrusive thoughts of the traumatic experience and hyperarousal in the first weeks after the disaster.[1] Long-term health effects of disasters include post-traumatic stress disorder,[2,3] depression and more general health complaints.[4,5] Complaints that are frequently reported after exposure to disasters or other stressful events include headache, fatigue, dizziness, concentrations problems and painful joints or muscles.[6–8] Often, no somatic explanation is found for the reported complaints, and they are labelled as medically unexplained symptoms or functional somatic disorders.[7,9,10] Such complaints are diffuse and non-specific, and they are commonly found in general populations.[10,11]

Health consequences of the exposure to a disaster have been studied mostly in retrospectively designed studies,[4,5,12,13] or when part of the sample was interviewed before and part after the disaster.[14] The availability of pre-crash and post-crash data from an on-going longitudinal study among older residents of the affected area in Amsterdam offered a unique opportunity to study changes in health in relation to the disaster. The hypothesis was tested that more negative changes in health over time are found in persons living closest to the crash area, when compared to persons living in areas at further distances from the crash site.

Methods

Sample

The Longitudinal Aging Study Amsterdam (LASA) is based on a nationally representative cohort, initial ages 55–85 years, with oversampling of men and older-old. The sample was recruited in 1992 (T_0) for the Study on Living Arrangements and Social Networks of older adults (LSN), which had a response rate of 62.3% ($n = 3805$).[15] The current study is restricted to older persons living in Amsterdam at T_0 ($n = 1066$). For T_0, all subjects were interviewed before the date of the disaster, October 4, 1992.

About 10 months after the LSN interview and at least 6 weeks after the disaster, the participants were approached for the first LASA cycle (1992–1993, T_1).[16] At this cycle, the Amsterdam cohort included 1028 surviving LSN participants (96.4%). Of the survivors, 865 subjects (84.1%) took part. By the second LASA cycle (1995–1996, T_2), 13.9% of T_1 participants had died. Of the 745 surviving participants, 699 (93.8%) were interviewed.[17]

Two analytic samples were defined for this study, to allow testing of both short-term and longer-term effects. The first (sample I) consists of those who participated at T_0 and T_1; the second (sample II), of those who participated at T_0, T_1 and T_2.

The sample of participants was subdivided according to residential distance from the disaster as a proxy for exposure: (1) those living >2 km from the disaster (i.e. residents of Amsterdam exclusive of the Bijlmer suburb, $n = 971$), (2) those living 1–2 km from the disaster (distant Bijlmer residents, $n = 56$), and (3) those living <1 km from the disaster (near

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Bijlmer residents, $n = 39$). Subsample (1) is used as the reference group.

Because the Bijlmer participants were significantly younger than those living in the rest of Amsterdam, the latter subsample was matched to the Bijlmer subsample on age, which procedure left 508 participants in this subsample.

Data

Distance to disaster was determined based on 6-digit postal codes. One apartment building is generally covered by several 6-digit postal codes.

Socio-demographics included sex and age, marital status (0 = married, 1 = never married, divorced and widowed), and socio-economic status (highest educational level attained and financial status based on the postal code) as measured at T_0.

Physical and mental health indicators were measured at all three cycles.

Functional ability was assessed using six self-report items, e.g. climbing up and down a staircase and cutting one's own toenails. Five response categories ranged from 'yes, without difficulty' to 'cannot'.[18,19] The six items were combined into one score ranging from 6 = unable to do all of the activities, to 30 = having difficulty with none of the activities. In addition, the interviewer was asked to rate the respondent's mobility on a nine-point scale ranging from 1 = very poor to 9 = very good.

Disability was assessed using an item from the Medical Outcomes Study on health problems limiting daily activities, coded as: 1 = no limitations, 2 = mild limitations, 3 = severe limitations.[20]

Self-rated health. A general question asking 'How is your health in general?' had five response categories ranging from 1 = very good to 5 = poor.[21] A second question added 'compared with your age peers' with five response categories from 1 = much better to 5 = much poorer. In addition, after the end of each interview the interviewer was asked to rate the respondent's general health on a nine-point scale ranging from 1 = very poor to 9 = very good.

Mental health consisted of interviewer observations of the respondent's cognitive functioning during the interview, including seven aspects such as attention, comprehension, and memory. Ratings on these aspects were summed to a score ranging from 0 = severe cognitive problems to 7 = no cognitive problems.[17]

Statistical analysis

First, group differences in mortality and other sample attrition at T_1 and T_2, respectively, were tested in relation to distance from disaster. Second, differences in socio-demographic variables were tested among the three distance groups. Those socio-demographic variables that showed significant differences, were included as covariates in further analyses.

Third, differences in rates of change in physical and mental health were evaluated using multivariate analysis of variance for repeated measures. For the analyses of the short-term effects, the pre-disaster and one post-disaster assessments were included in the test of within-subjects effects (sample I). For the analyses of the longer-term effects, the pre-disaster and two post-disaster assessments were included (sample II).

Results

Attrition

In the full study sample, the refusal rate at T_1 was much greater than at T_2, whereas the mortality rate increased gradually (table 1).[17] There were, however, differences among subsamples.

Non-mortality attrition appeared to be greater in the Bijlmer subsample nearest the disaster, but smaller in the distant Bijlmer subsample (relative risks of attrition compared to the reference sample at long-term follow-up: RR = 1.77 and 0.47, respectively, $P = 0.064$). In the full study sample, non-mortality attrition between T_0 and T_1 and between T_0 and T_2 was associated with poorer baseline health on all indicators except self-reported disability. These associations did not differ among subsamples, with one exception between T_0 and T_1; whereas in the reference sample, baseline self-reported functional ability was worse among those who refused, in the Bijlmer samples baseline self-reported functional ability did not differ between the refusers and the continuing participants.

Table 1 Attrition in three subsamples by distance from disaster

	n			Non-mortality attrition (%)		Mortality (%)	
	T_0	T_1	T_2	T_1	T_2	T_1	T_2
(1) >2 km	508	407	337	15.9	20.7	3.9	13.0
(2) 1–2 km	56	51	41	7.1	13.0	1.8	16.1
(3) <1 km	39	28	21	20.5	30.8	7.7	15.4

Mortality did not differ significantly across the subsamples. In the full sample, mortality was associated with all baseline health indicators except self-reported disability. For all interviewer-rated indicators, however, the reference sample and the Bijlmer subsamples showed different associations: whereas the expected associations were observed in the reference sample, in the Bijlmer subsamples no associations between interviewer-rated health and mortality were observed.

These findings indicate a tendency for both mortality and non-mortality attrition to be less influenced by baseline health status in the Bijlmer residents than in the subjects living outside the Bijlmer suburb.

Baseline characteristics

The average initial age of the study sample was 68.2 years. Comparison of the subsamples with respect to age, education, income and marital status did not yield significant differences at $P < 0.05$ (table 2). The percentages of females and of unmarried respondents were somewhat smaller in the Bijlmer subsamples ($P = 0.058$ and 0.087, respectively). The marital status difference disappeared when stratifying by sex, due to the much higher likelihood of women being unmarried at older ages. Because of the uneven distribution of sex in the subsamples, sex is included as a covariate in the analyses of health outcomes.

The health indicators showed few differences across the subsamples at baseline. Self-reported disability was slightly greater in the distant Bijlmer subsample ($P = 0.039$). Self-reported general health was slightly worse in both Bijlmer subsamples ($P = 0.058$).

Health outcomes

Significant declines in *self-reported functional ability* between T_0 and T_1 were demonstrated in sample I (table 3, main effect). The rates of decline were different for specific subsamles, as the interaction term between time, distance to disaster, and sex was significant. This indicates that females declined more than males, except in the subsample nearest to the disaster.

A significant decline in self-reported functional ability was also apparent over the period of four years, as demonstrated in sample II (table 3). Here, the interaction term between time and distance to disaster was significant, but a three-way interaction with sex no longer showed significance. This indicates that the

Table 2 Baseline socio-demographic and health characteristics of three subsamples by distance from disaster

	(1) < 1 km	(2) 1–2 km	(3) > 2 km
Age: % 75–85 years	31.9	27.5	21.4
Sex: % females	49.0	44.6	33.3*
Education (% low)	39.9	45.5	33.3
Income (% low)	41.2	39.3	46.2
Marital status (% unmarried)	41.5	28.6	33.3*
SR functional ability	22.7	25.6	25.2
SR disability	1.4	1.7	1.5**
IR mobility	7.2	7.2	7.1
SR health general	2.7	2.7	2.5*
SR health age peers	2.4	2.7	2.7
IR general health	7.0	7.2	6.9
IR cognitive functioning	5.0	5.2	5.1

*$P < 0.10$; **$P < 0.05$.
SR, self-reported; IR, interviewer-rated.

Table 3 The association between distance to disaster and changes in health outcomes in sample I (T_o to T_1) and sample II (T_o to T_2): significance tests from multivariate analysis (*P*-values)

	SR functional ability	SR disability	IR mobility	SR health general	SR health age peers	IR general health	IR cognitive functioning
Main effect time							
Sample I	0.04	0.13	<0.001	0.04	0.11	0.11	0.43
Sample II	<0.001	0.18	<0.001	0.09	0.12	<0.001	<0.001
Interaction time × distance							
Sample I	0.39	0.24	0.02	0.19	0.11	0.004	0.09
Sample II	0.001	0.72	0.27	0.49	0.32	0.33	0.09
Interaction time × distance × sex							
Sample I	0.007	0.97	0.46	0.79	0.94	0.60	0.62
Sample II	0.60	0.46	0.32	0.25	0.21	0.41	0.69

SR, self-reported; IR, interviewer-rated.

longer-term rate of decline was greatest in the subsample nearest to the disaster, and that the longer-term rates of decline no longer differed by sex (figure 1).

There were no significant main or interaction effects for *self-reported disability*, either in sample I or in sample II (table 3).

Interviewer-rated mobility showed significant declines over time (table 3). Moreover, in sample I the interaction effect between time and distance to disaster was significant, indicating that the short-term decline was greater in the Bijlmer respondents. However, in sample II the longer-term differences in rates of decline did not reach significance (figure 2).

The respondents' *self-rated health* 'in general' showed a significant decline over time (table 3). However, since none of the interaction terms were significant, this decline was not different across the subgroups. This was true for both the short term and the longer term. Self-rated health in comparison with age peers showed no significant decline (table 3).

Interviewer-rated health showed a significant interaction effect of time and distance to disaster in sample I (table 3). As opposed to the Amsterdam respondents outside the Bijlmer suburb, the Bijlmer respondents showed short-term declines. In sample II, the main effect of decline was significant. However, the decline no longer differed significantly across the subsamples.

Cognitive functioning as rated by the interviewers showed no significant change over time in sample I (table 3, main effect). In sample II, the main effect of cognitive functioning was significant, indicating a decline over the four-year period (table 3). In both samples, however, the interaction term of time with distance to disaster was marginally significant ($P = 0.09$). The mean scores showed a continuous decline in the reference sample. In contrast, in both Bijlmer subsamples, an initial increase was observed, followed by a decrease in cognitive functioning from T_1 to T_2 (figure 3).

Discussion

This study examined short-term and longer-term health effects of a disaster by making use of data from an ongoing longitudinal study with its initial data collection cycle a few months before the disaster, and subsequent data collection cycles a few months and several years after the disaster. As expected, more negative changes were observed on several indicators of health in those subjects who lived closest to the site

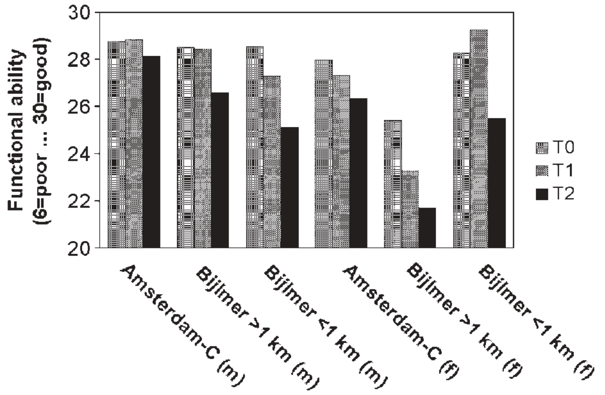

Figure 1 Bijlmer disaster and change in self-reported functional ability, men (m) and women (f)

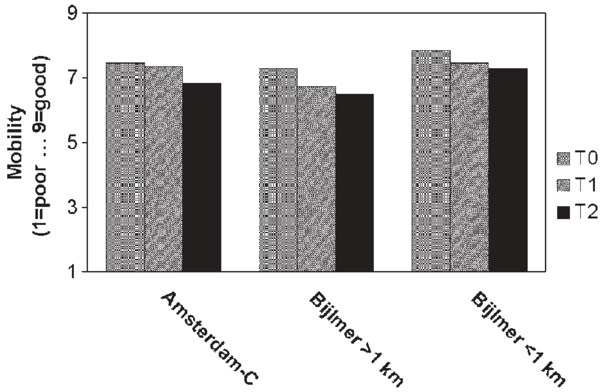

Figure 2 Bijlmer disaster and change in interviewer-rated mobility

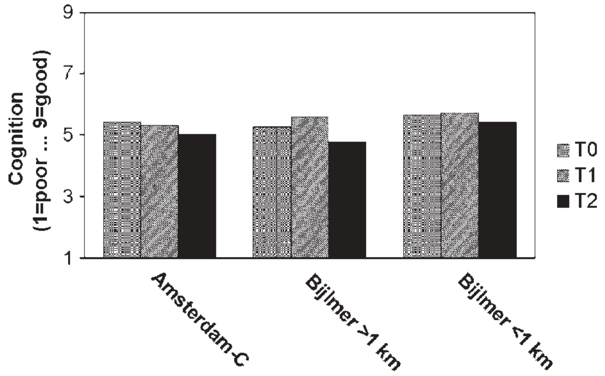

Figure 3 Bijlmer disaster and change in interviewer-rated cognitive function

of the disaster. This was true for self-reported functional ability, interviewer-rated mobility and interviewer-rated general health. The more negative changes in mobility and general health were only apparent shortly after the disaster. Self-reported disability and self-rated health did not show differences in rate of change among subjects living at shorter or longer distance from the site of the disaster. There were also no differences in mortality.

Other studies have suggested that disasters may result in various health effects.[1–13] The findings of the present study suggest that the risk of negative health outcomes associated with a disaster is not pervasive across health indicators. There are a series of tentative explanations for this finding. First, functional ability, mobility and disability are concepts on one continuum, referred to as the disablement process.[22] Limitations in functional ability, including mobility limitations, occur earlier in the process than disability, as functional limitations denote the inability to perform actions that are needed to carry out an activity. Such actions are not activities in themselves. Disability denotes restrictions in activities, in particular in role functioning. Functional limitations, then, may be a more sensitive measure of changes in health than disability. A more mundane reason for the lesser sensitivity of the disability measure that was used in this study, may be the shortness of its scale. With only three response categories, its sensitivity to change is likely to be limited.

Second, there is ample evidence for the relative stability of self-perceptions of health. Especially in older persons, who are often faced with inevitable health problems, self-rated health has been shown to be better than expected, based on objective health status.[23,24] This relative stability is reflected by the barely significant longer-term decline in self-rated health in our sample. Interestingly, interviewer-rated general health did show longer-term decline, as well as greater short-term declines in the subsamples nearest to the site of the disaster. A stabilizing 'trait'-component that may be at work in the respondents' self-ratings, is absent in the interviewer ratings. Therefore, the interviewer ratings may be more sensitive to changes over time. However, as the interviewers were aware that the Bijlmer respondents had experienced a recent disaster, they may have given a lower rating to these respondents' general health. This possibility of an existence of interviewer bias, however, is not confirmed by the interviewer ratings of cognitive functioning, that were higher shortly after the disaster. Moreover, the interviewers at T_0 were not the same as at T_1, and they did not know the T_0 ratings.

Interviewer-rated cognitive functioning showed short-term improvement in those subjects living nearest to the site of the disaster. This unexpected finding deserves a special note. The interviewer observation of cognitive functioning included aspects such as attention and understanding. Possibly, feelings of anxiety related to the recent experience of the disaster may produce a heightened level of arousal and alertness, which in turn leads to improved cognitive functioning. The finding that after this brief improvement cognitive functioning declined at a normal rate, shows correspondence with what is known about the effects of stress: in the short term, stress may have beneficial effects on functioning, whereas continued stress has detrimental long-term effects.[25]

As the LASA study was not initiated to address the specific issue dealt with in this study, there are a number of limitations. First, the available exposure measure, residential distance from the disaster, is used as a proxy for actual experience of the disaster. This approach assumes that the event of the crash affects all respondents in a distance-based subsample equally, and ignores differences in subjective experience and coping. Nevertheless, such differences are highly likely, considering that some actually suffered the loss of a loved one or of their home, whereas others only heard from the suffering of distant neighbours. The lack of more detailed exposure measures in our study may result in an underestimation of the effects. Second, the subsample living nearest to the site of the disaster was small. Moreover, it suffered from considerable attrition, so that for the examination of longer-term effects only 21 subjects were left in the near Bijlmer subsample. Although mortality rates did not differ among the subsamples, non-mortality attrition did show differences and may be a source of bias. However, both mortality and non-mortality attrition were less influenced by health status in the Bijlmer residents than in the subjects living outside the Bijlmer suburb. This implies that the continuing participants in the Bijlmer subsamples were not excessively selective with respect to the outcome variables. Third, this study was necessarily based on the general health indicators that were available both at the pre-disaster and post-disaster data collection cycles. Thus, specific aspects of health that may be more closely related to the experience of a disaster, such as post-traumatic stress disorder, could not be investigated.

On the other hand, the availability of general health indicators may be considered as a strength of this study, as there is very little research on changes in general health in relation to a disaster.

In all, the limitations of this study are offset by the availability of a pre-disaster measurement. Inevitably, studies that are explicitly initiated to investigate the health effects of a disaster have post-disaster measurements only, which hampers interpretation of differences between subjects exposed and not exposed.

A final note concerns the older age of the sample studied. The question may be raised whether results among older residents can be applied to the total Bijlmer population. First, the population aged 55 and over forms a relatively small minority in the Bijlmer suburb. Second, older persons may show different reactions to a disaster than younger ones.[26] On the one hand, older persons are more frail and may thus be more vulnerable to the effects of a disaster than younger persons.[27] On the other hand, older persons may be less reactive to stress events ('maturation'), or, in their longer lives, may have had to deal with similar disasters, which may make it easier to cope with the more recent one ('inoculation').[28] A study among both younger and older adults, could clarify age differences in these possible reactions.

In conclusion, this study shows that older persons are likely to experience negative health changes in the wake of a disaster, over and above the negative health changes that occur normally with aging. Because a disaster affects all people living in an affected area, its public health consequences may be considerable. Nevertheless, it should be noted that the disaster-related health declines were small, and most obvious in the ability to perform actions (such as mobility), but were neither observed in disability in daily functioning, nor in self-perceptions of health. These findings may be interpreted as indicative of substantial resilience in older persons, despite their additional health problems.

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Key points

- This longitudinal study among older residents examines the health impact of an aeroplane crash on a densely populated suburb.
- Post-disaster mobility was significantly decreased as compared to pre-disaster mobility in those living nearest to the site of the disaster.
- A similar decrease was not observed for self-rated health and self-reported ability to perform daily activities.
- For cognitive functioning, a temporary improvement was seen following the disaster.
- As the disaster affected the total population, the public-health effects of even small disaster-related health declines are considerable.

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